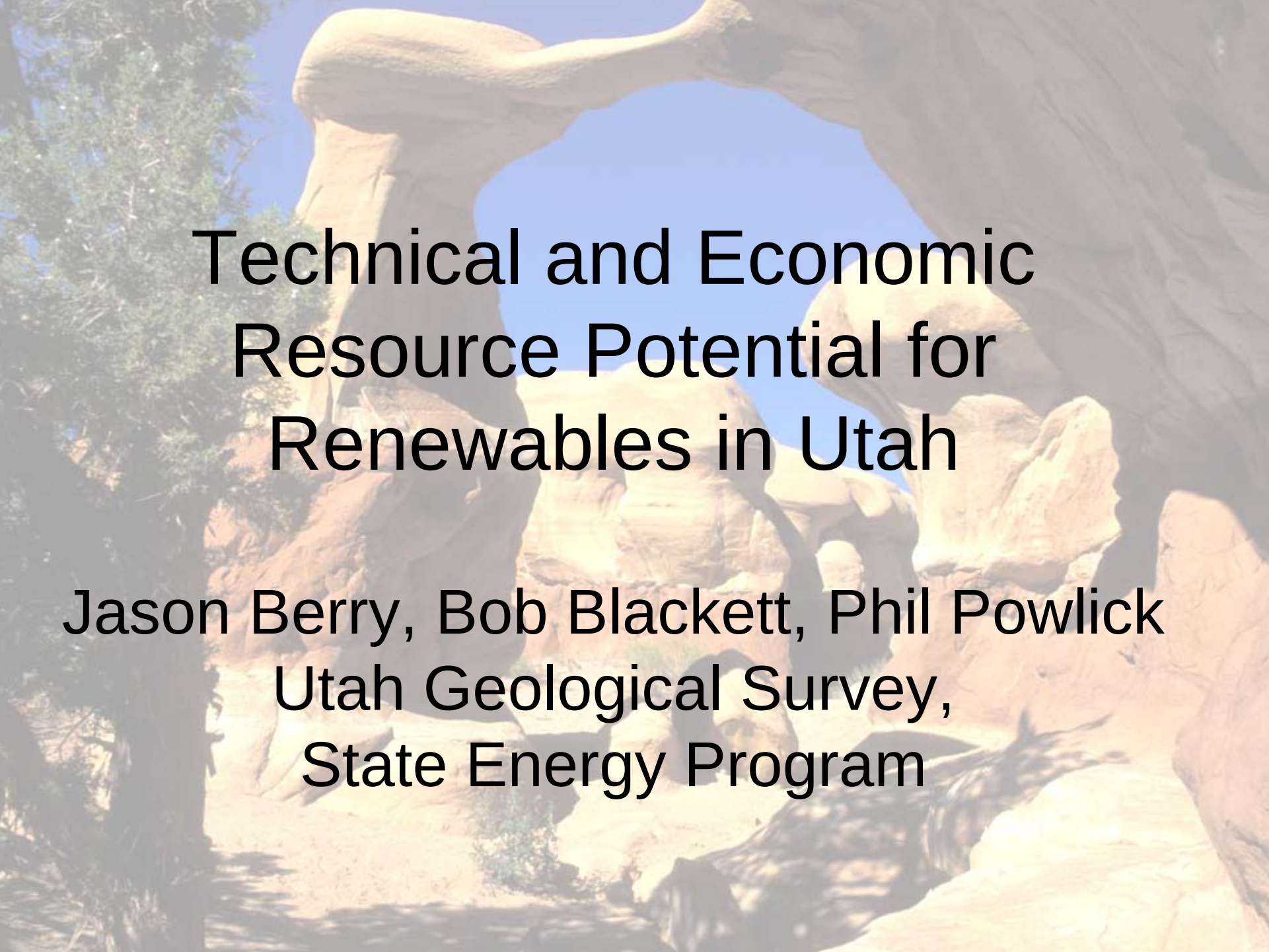


Technical and Economic Resource Potential for Renewables in Utah

Jason Berry, Bob Blackett, Phil Powlick
Utah Geological Survey,
State Energy Program

Overview

- Technical Potential = What is possible, economics not considered
- Economic Potential = What is likely to be done given economic parameters
  - Cost per kWh and capacity costs primary in this presentation
  - Other intangible values included where appropriate
  - We DO NOT try to factor in a price for carbon
- Technology review limited
  - Solar PV, Geothermal, Concentrating Solar, Wind
  - Other technologies possible but likely very small portion of electricity portfolio
    - E.g. Biomass, landfill methane, sewer methane

Geothermal Resources

- Focus on best-known development areas
  - Other areas possible, but public data are not available
  - Need for exploration?
- Detailed study done by WGA (Jan. 2006)
  - CDEAC Geothermal Work Group
  - http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

Geothermal Development Costs, Example for Ormat (Nevada)

DRILLING AND WELL FIELD DEVELOPMENT

Medium risk – Investor Financing Possible

- Production/injection wells $1.0 to $3.0M each
- Production wells provide between 3MW and 30MW
- One injection well serves two or more production wells
- Well drilling success averages over 70%
- 3,000 foot average depth – Assume $1.5 M per well

20 MW Nevada project: 7 prod. & 3 inject. wells

Budget for 10 wells @3,000 feet depth is $15M
Timetable including permitting would be 12 to 18 months

Geothermal Development Costs, Example for Ormat (Nevada), cont'd

PROJECT DEVELOPMENT BUDGET 20MW

Uses of Funds

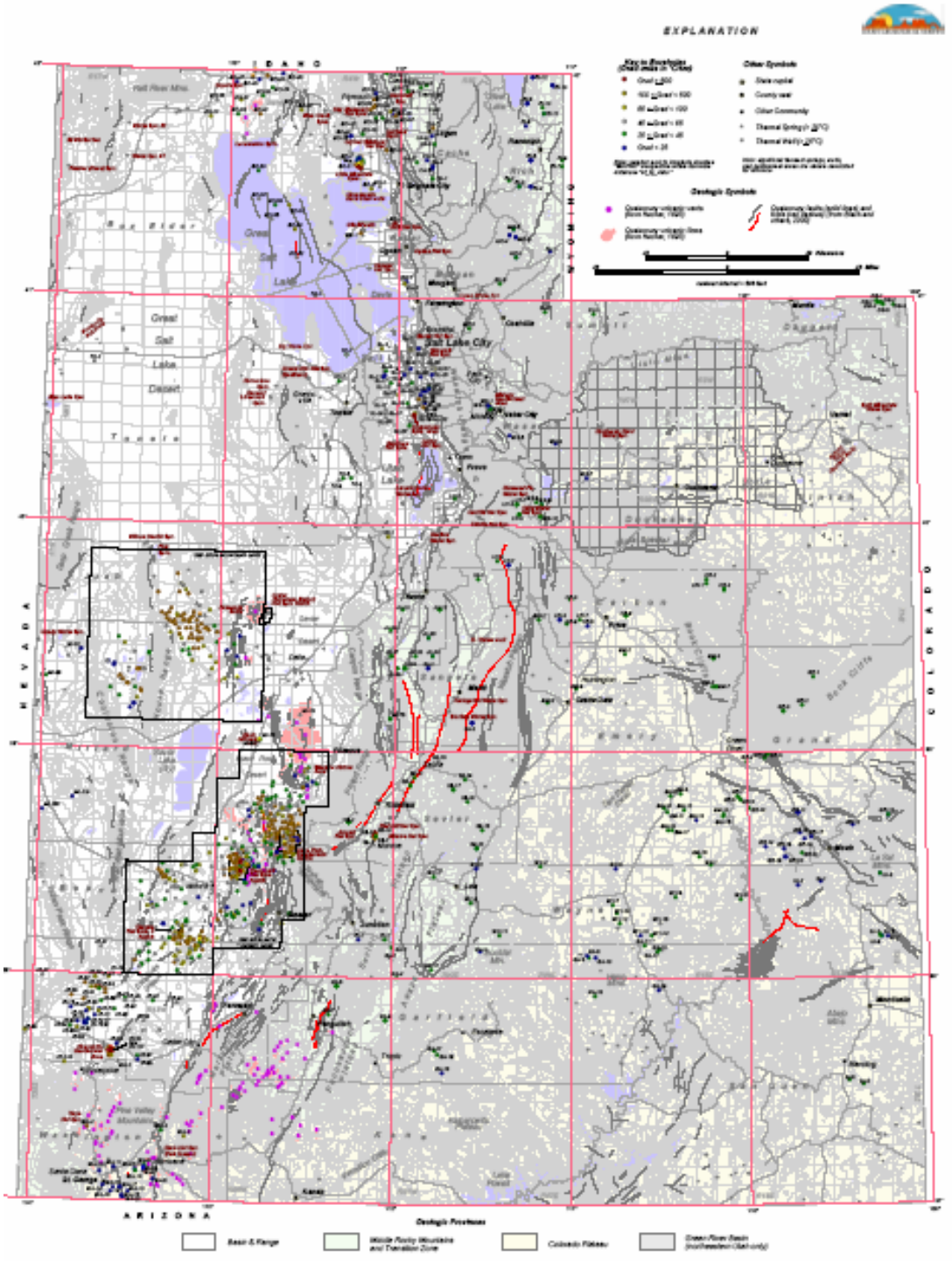
Exploration & resource assessment	**$ 5.0 M**
Well field drilling and development	**15.0**
Power plant, surface facilities, & transm.	**30.0**
Financing "soft costs" including:	**5.0**

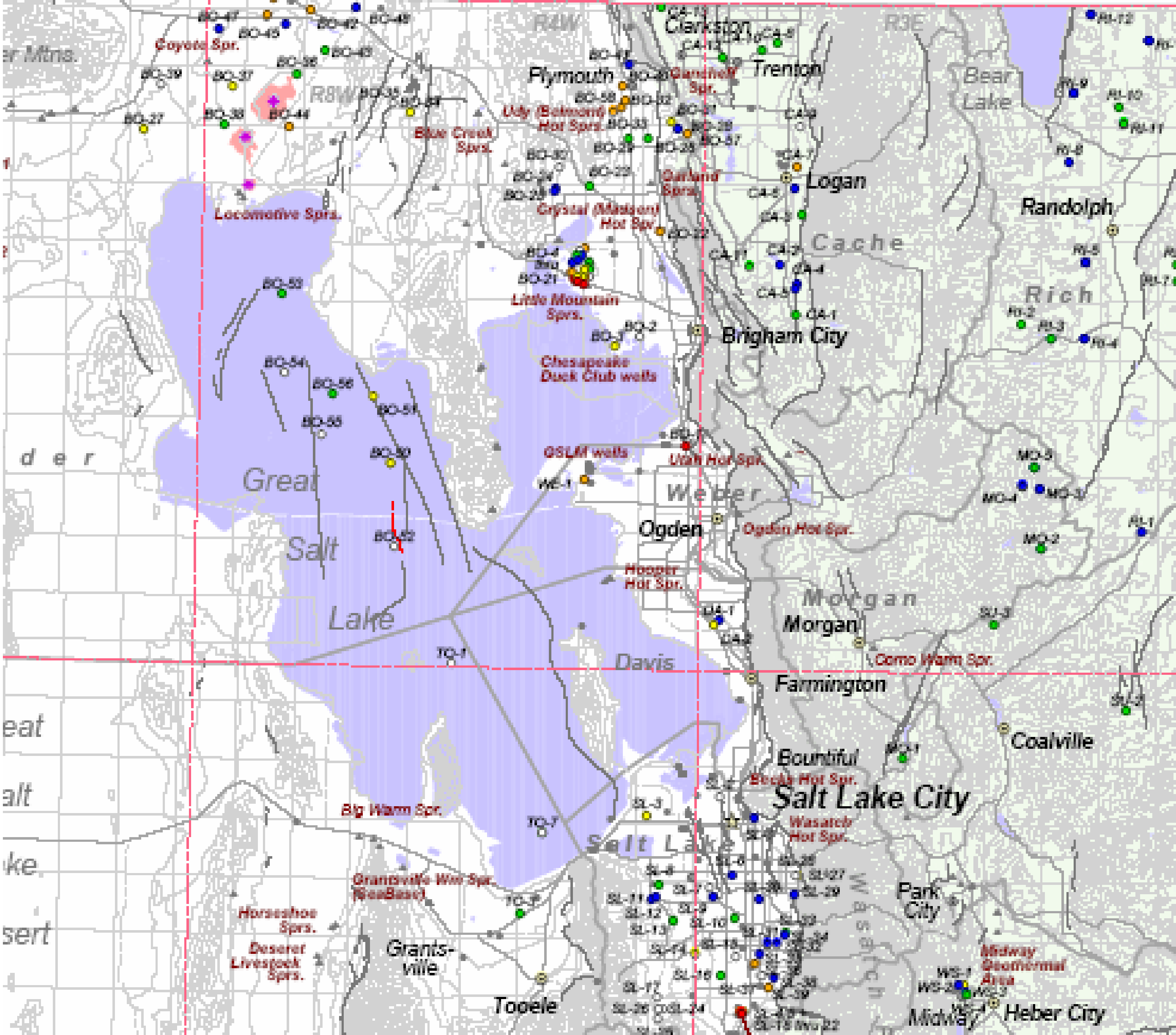
- **Commitment fees**
- **Legal & accounting fees**
- **Consultants, and**
- **Interest during construction**
- **Debt service and operating reserve**

TOTAL *FINANCED* COST FOR 20MW PROJECT $ 55 M

To be provided as construction phase financing

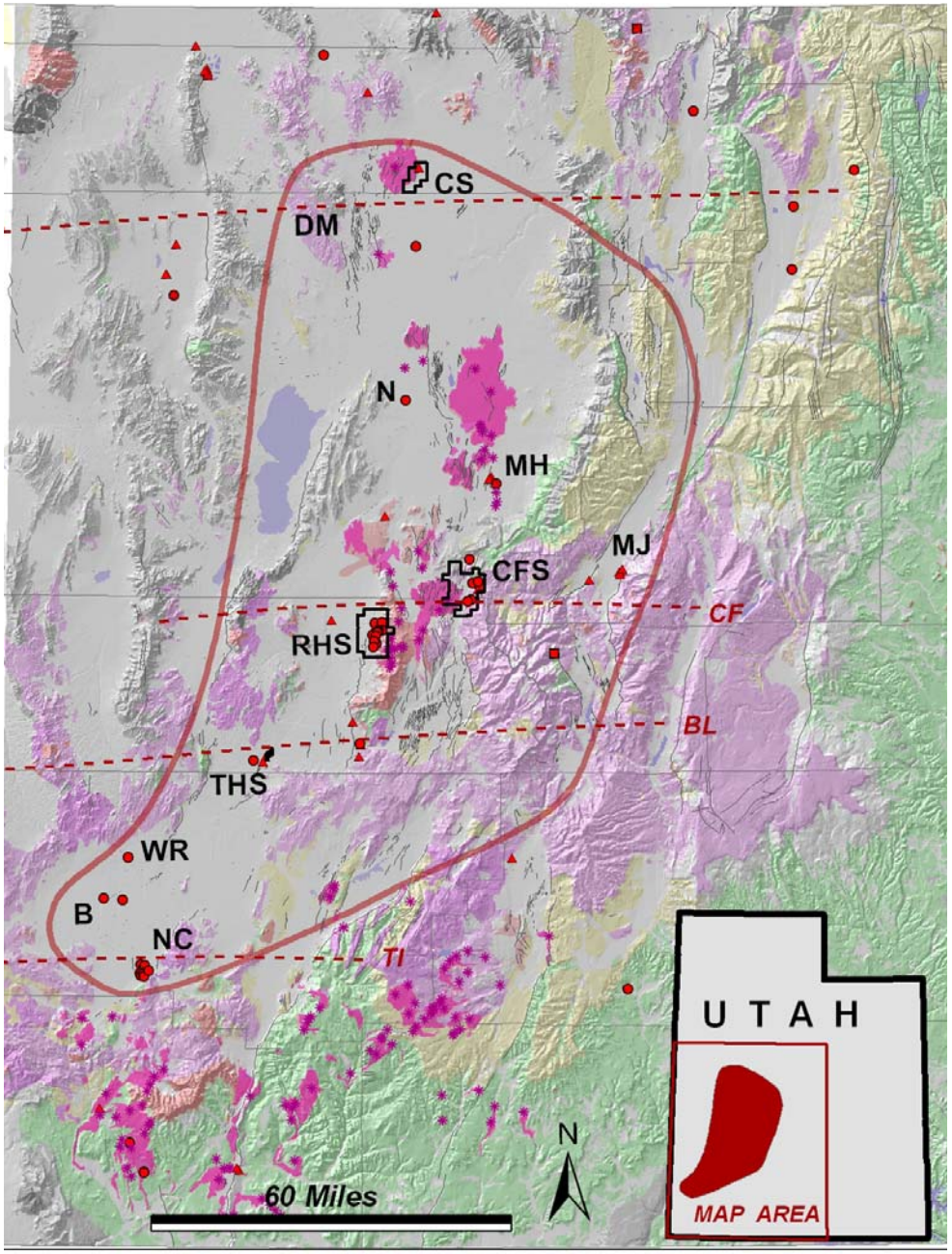
Utah Overall Geothermal Information





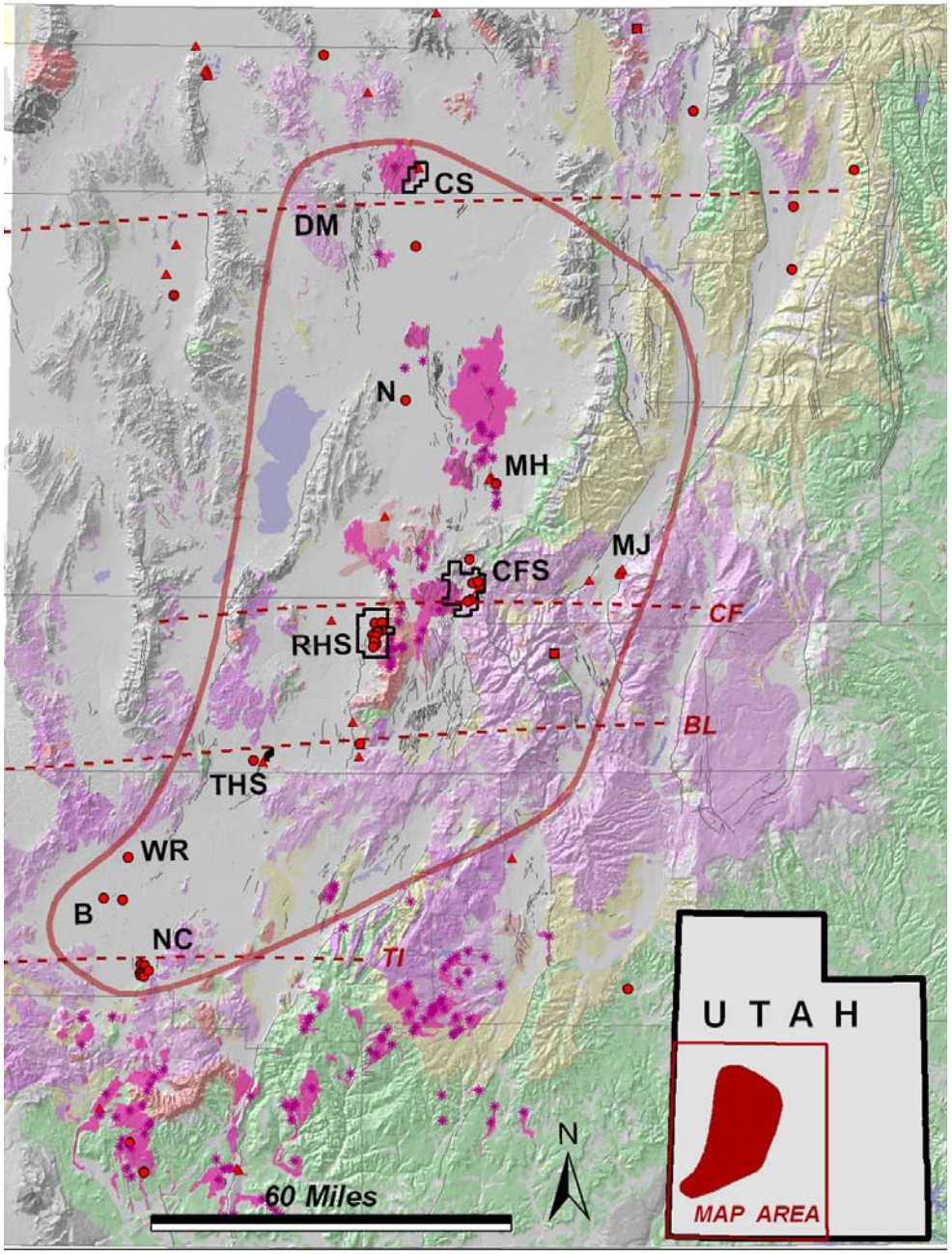
Clarkston
Trenton
Plymouth
Logan
Randolph
Bear Lake
Brigham City
Ogden
Morgan
Farmington
Coalville
Bountiful
Salt Lake City
Park City
Heber City
Midway
Grants-ville
Tooele
Great Salt Lake
Cache
Rich
Weber
Morgan
Davis
Salt Lake
R4W
R3E
R8W
Coyote Spr.
Locomotive Sprs.
Blue Creek Sprs.
Udy (Belmont) Hot Sprs.
Crystal (Madsen) Hot Spr.
Garland Sprs.
Little Mountain Sprs.
Chesapeake Duck Club wells
GSLM wells
Utah Hot Spr.
Ogden Hot Spr.
Hooper Hot Spr.
Como Warm Spr.
Becks Hot Spr.
Wasatch Hot Spr.
Big Warm Spr.
Horseshoe Sprs.
Deseret Livestock Sprs.
Midway Geothermal Area

Sevier Thermal Area



- **Located in Southwestern Utah**
- **Eastern Basin & Range province and Transition Zone**
- **Has most of the identified moderate and high-temperature geothermal systems in Utah**

STA Geothermal Areas



- RHS - Roosevelt Hot Springs
- CFS – Cove Fort-Sulphurdale
- DM - Drum Mtns.
- CS - Crater Springs
- N - Neels RR Siding Well
- MH - Meadow-Hatton
- MJ - Monroe-Joseph
- THS - Thermo Hot Springs
- B – Beryl
- WR - Woods Ranch
- N - Newcastle

WGA Geothermal Summary - Utah

Resource Area	Resource Capacity Values (MW)		Expansion	Cost Allocations	
	Near-Market cost up to 8 c/kWh online within 10 years	Longer-Term cost up to 20 c/kWh online within 20 years		Capital	O & M
				$/kW	cent/kW-hr
Cove Fort-Sulphurdale	50	200	e	3500	2.2
Roosevelt Hot Springs	100	250	e	3500	1.8
Thermo Hot Springs	50	100		3500	2.2
Newcastle	10	20		3500	2.2
Other (Monroe, Mineral Mts., etc.)	20	50		3500	2.2
Utah Total	*230*	*620*			

WGS Geothermal Estimate in Perspective

- 230 MW of capacity by 2016 @ 85 CF= 1,713 Gwh / yr
  - 6.5% of 2006 Utah consumption (26,361 Gwh)
  - 5.3% of 2016 Utah consumption (32,134 Gwh)
- 620 MW of capacity by 2026 @ 85 CF= 4,617 Gwh / yr
  - 17.5% of 2006 Utah consumption (26,361 Gwh)
  - 11.8% of 2026 Utah consumption (39,171 Gwh)

Solar PV Potential

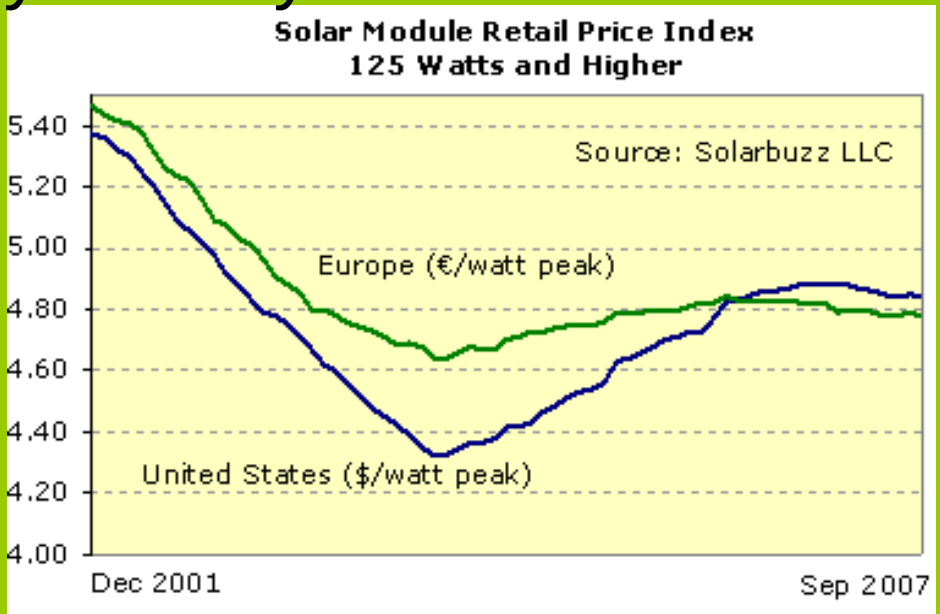
- Technical potential is vast…
  - If you want to cover most of the state in solar panels
- Large technical potential even placing PV panels only on existing buildings
  - If 1 kW on each existing homes in UT (785,000), 785 MW capacity (11.5% of current)
    - But low capacity factor; avg. = 17%
    - Generation would = 1,169 GWh or 4.4% of current consumption (3.7% of 2015 consumption)
    - Cost = $6.28 billion (assuming $8,000 / kW capacity)
    - Cost borne through current tax credits; Utah = $1.57B, Fed = $1.41B

Solar PV Potential, cont'd

- Costs can be reduced somewhat by installing only on new buildings
  - Assume all new homes built in UT 2008-2015 have 1 kW PV installed
    - @ 24,000 / year; 192,000 total
    - 1 kW per home @ $7,000 / kW
    - 192 MW capacity; 285 GWh in 2015
      - 1.1% of current consumption; 0.9% of 2015 consumption
    - Total cost = $1.34 billion
    - Cost borne through current tax credits; Utah = $336M, Fed = $302M

PV Cost Projections

- WGA Solar Task Force Report
  - Projects 75 MW for capacity potential for Utah by 2015
  - Shows current costs @ 20 to 30 cents / kWh
  - Projects drop to 10 to 15 cents by 2015 IF PV deployment grows by 32% / year in the West
    - Assumes prices drop as production efficiency climbs
    - Or will increasing demand cause prices to rise ?



More Cost Estimates

- SEIA
  - Central PV Current = 20 to 30 cents
  - Distributed PV = 20 to 50 cents
- UT SEP (price / kWh for 20 yr payback)
  - Small PV, no financing, fed credits = 23.5 cents
  - Small PV, 7% interest, fed credits = 43.7 cents
  - Large PV, no financing, fed credits = 18.0 cents
  - Large PV, 7% interest, fed credits = 35.0 cents

What is Value of PV?

- Zero emission (comparable to other RE)
- Solar PV is roughly peak following
  - Mona hub prices (wholesale), past year
    - Peak = 6.3 cents / kWh
    - Offpeak = 3.8 cents / kWh
    - Other regional hub prices comparable
- Resource availability more predictable than wind
  - But less so than geothermal
- Distributed PV improves robustness of grid
  - Can reduce need for new peaking capacity
  - Local back-up power
  - Reduces need for transmission and T&D costs
- Resource is widespread
  - Systems can be deployed where needed

PV Summary

- Technical potential is vast
- Technological hurdles few
- Capacity and kWh price is high
- But non-monetized benefits exist
- Key Question: How much are PV benefits worth when compared to other alternatives (fossil and renewable)?

Concentrating Solar Power in Utah

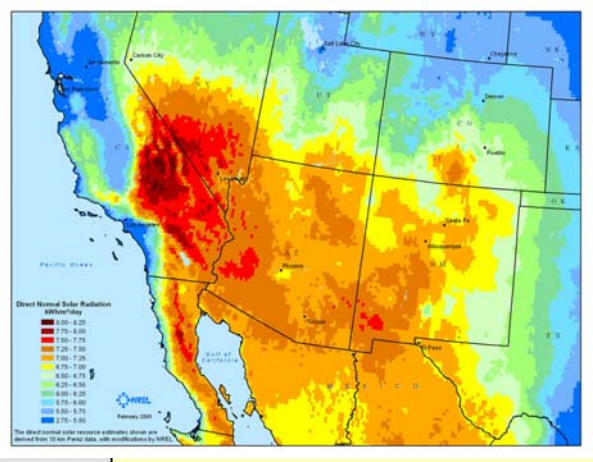
DOE—NREL study of CSP in the Southwest

What is the cost of energy for each increment in CSP capacity?

Analysis requires knowledge of the following:

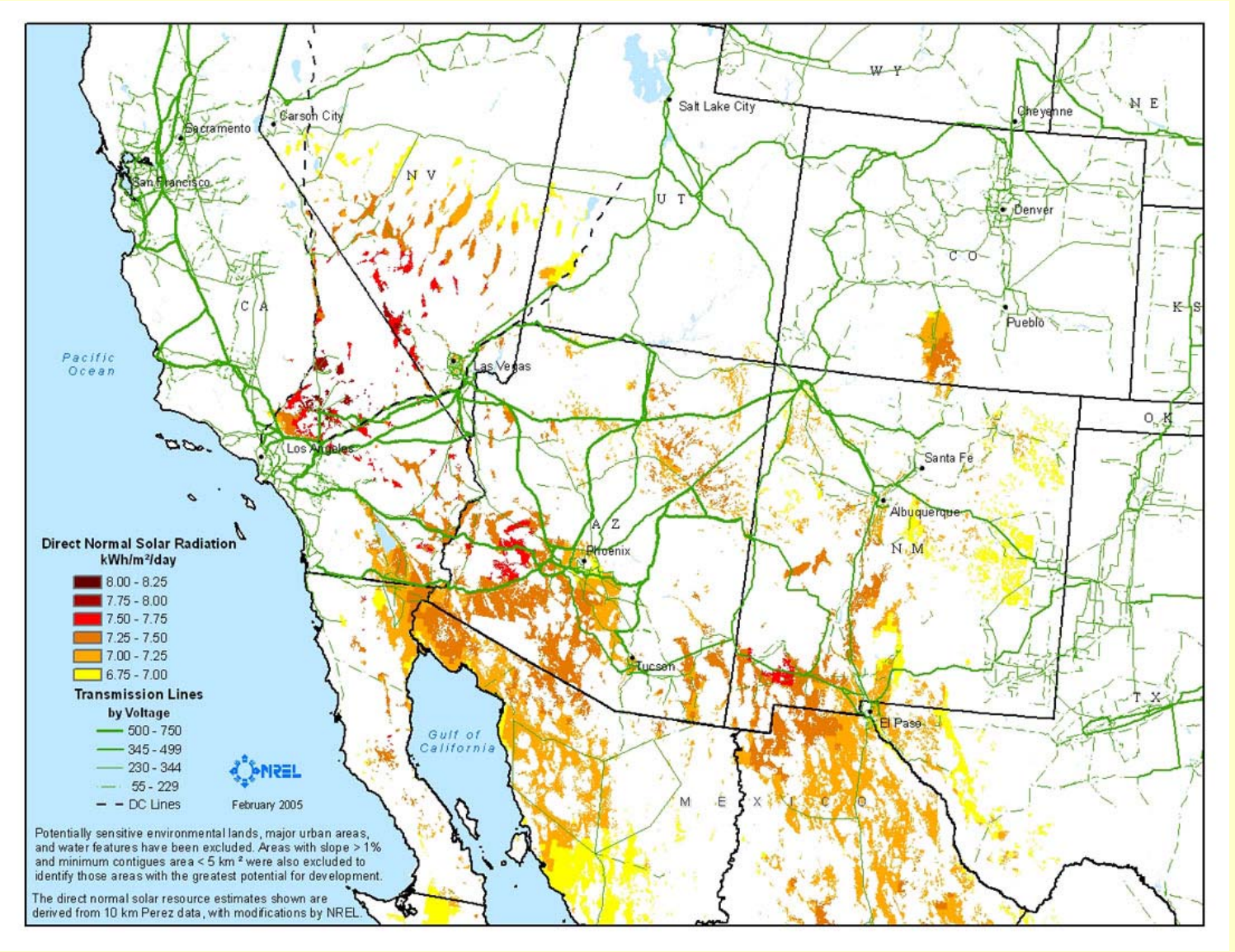
- Solar Resource
- Land Availability
- Proximity to Transmission
- Availability of Transmission
- Cost to Generate Power

DOE CSP Study
1000MW Analysis



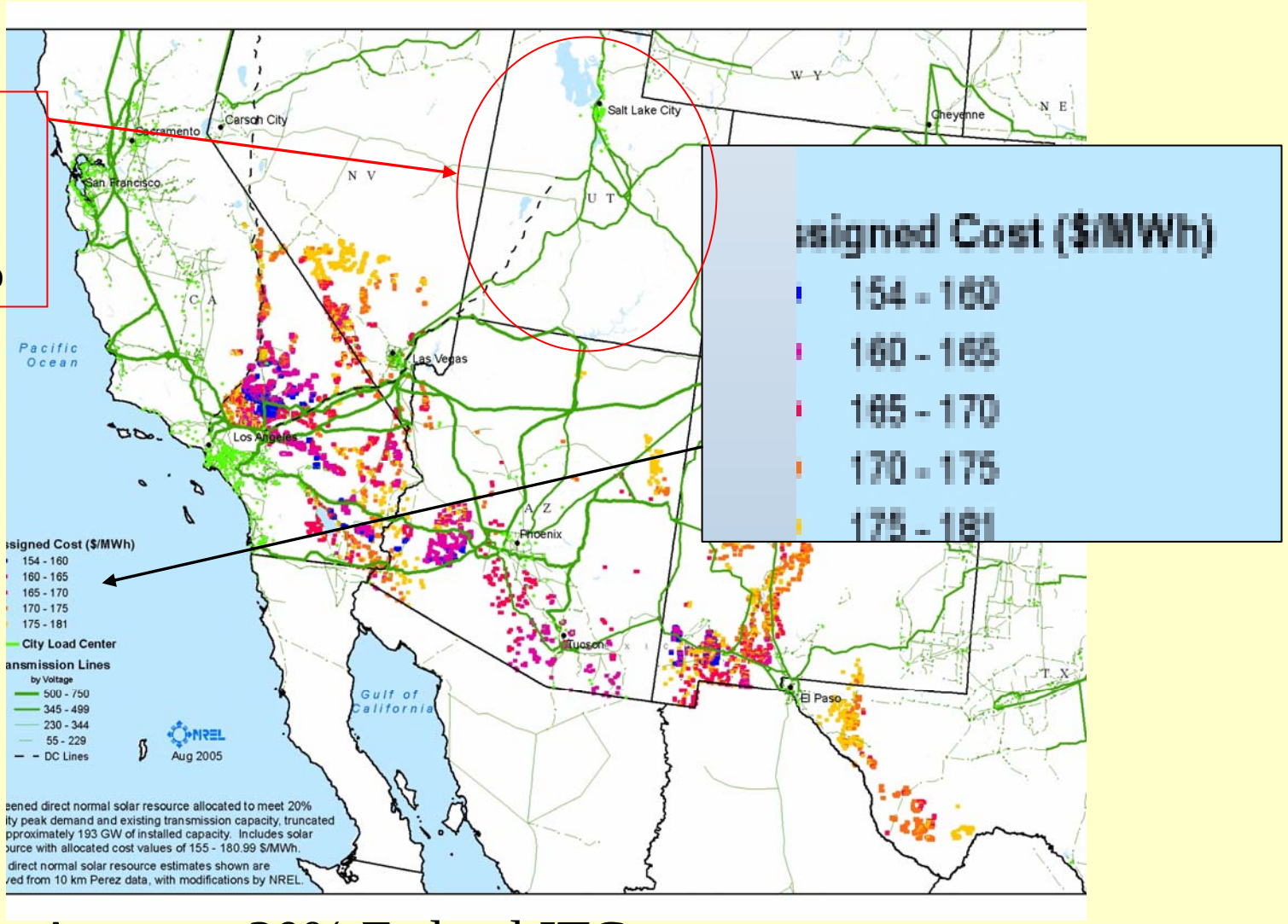
Southwest Solar Resources

Prior plus Slope < 1%



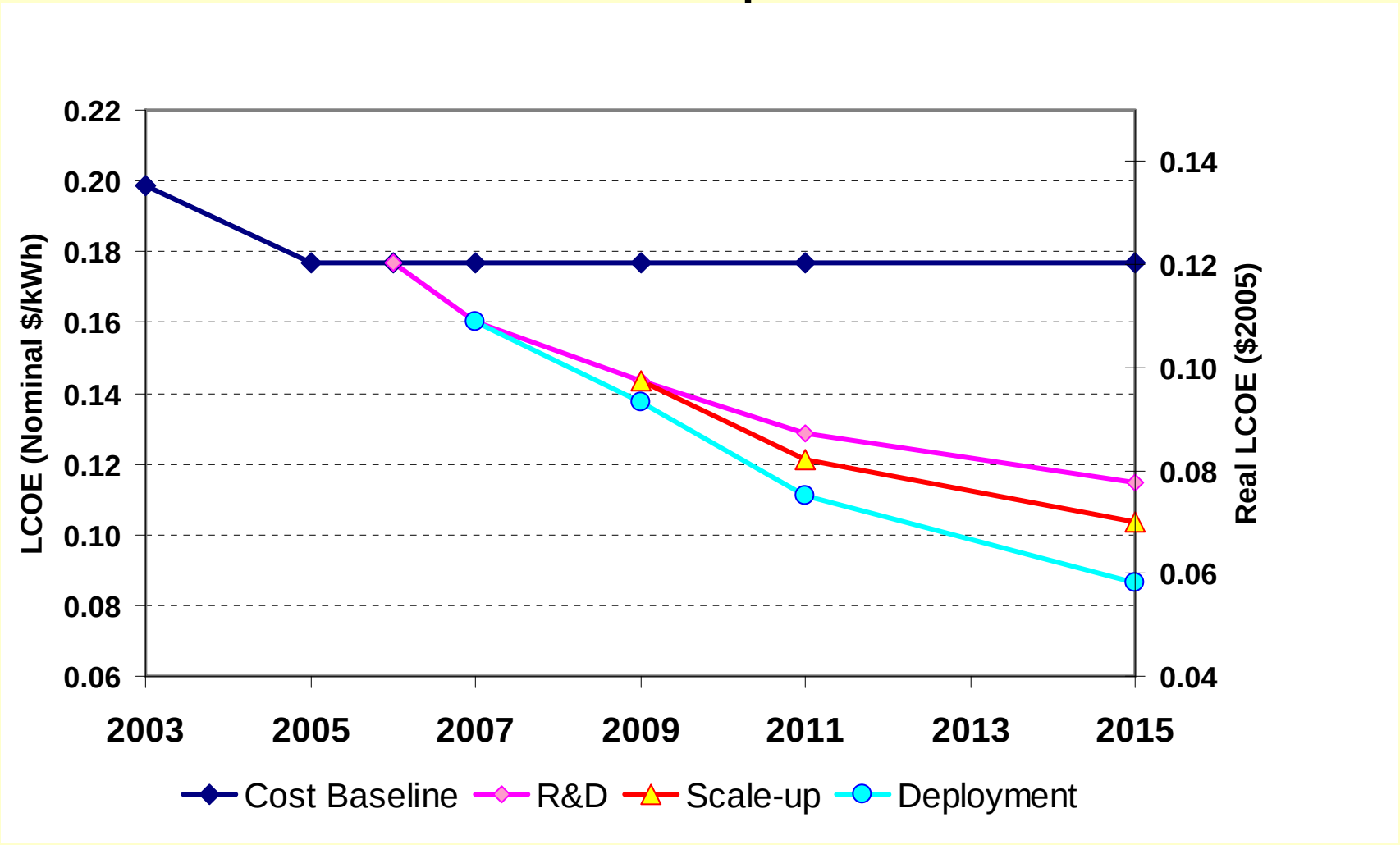
DOE's Findings for Optimal Locations for 2GWs of CSP Capacity in Southwest U.S.*

Models shows no UT development under scenario



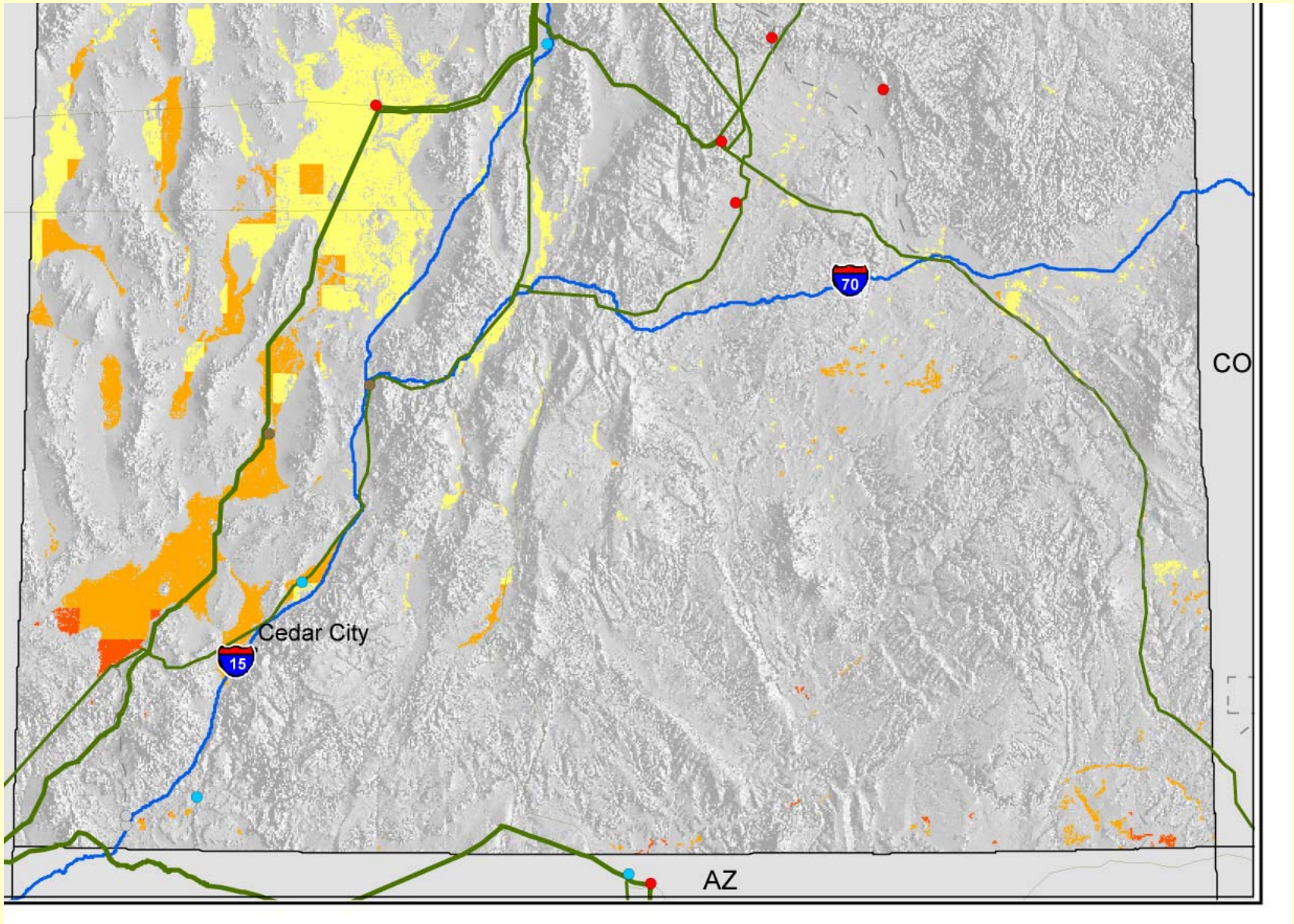
Assumes 30% Federal ITC

DOE's Cost Reduction Projections w/ 2000MW market penetration*

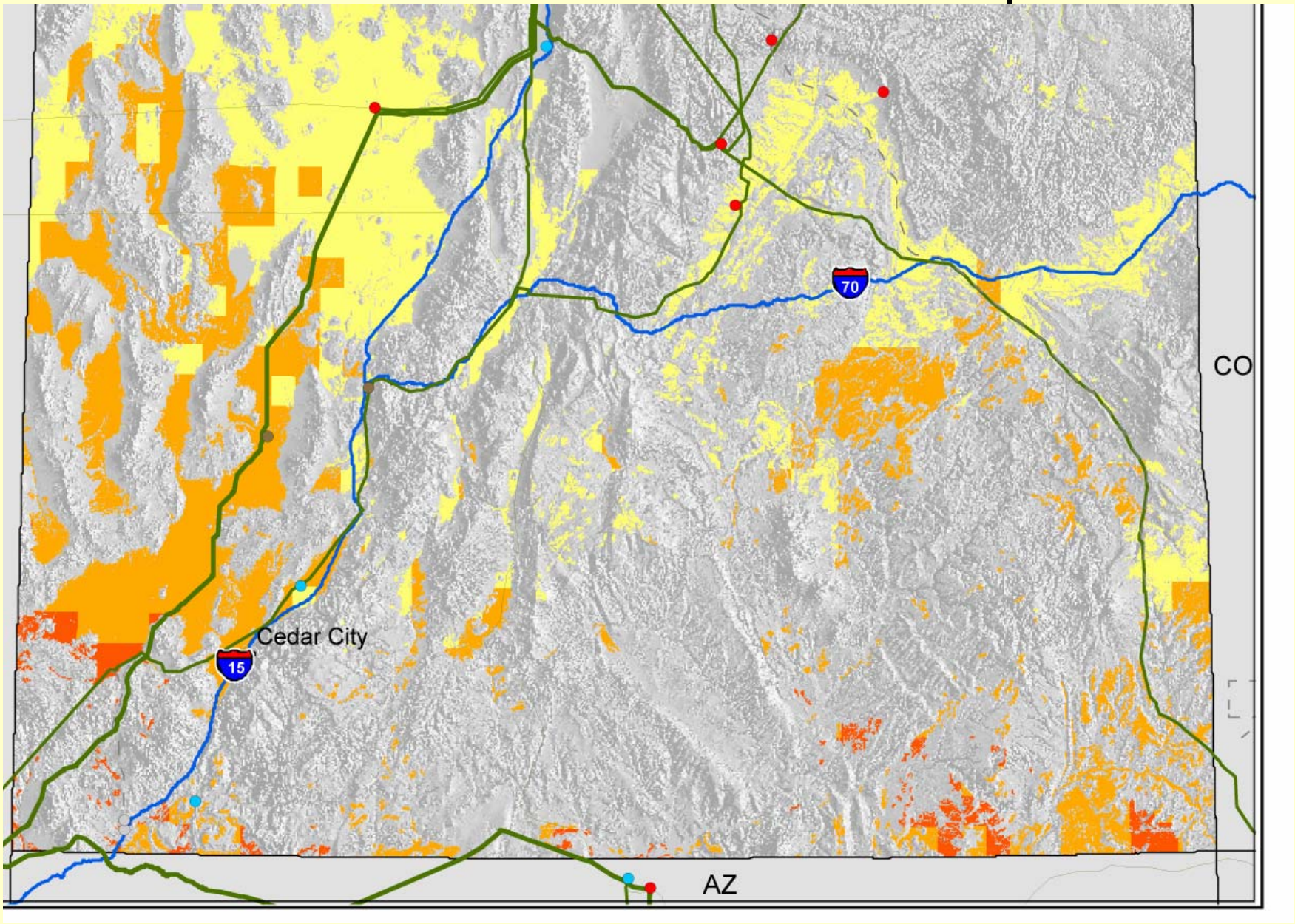


*using solar resource of Barstow, CA (7.75-8.06 kW/M2/day. Utah's best is 7.25-7.49).

Utah CSP locations <1% slope



Utah CSP locations <3% slope



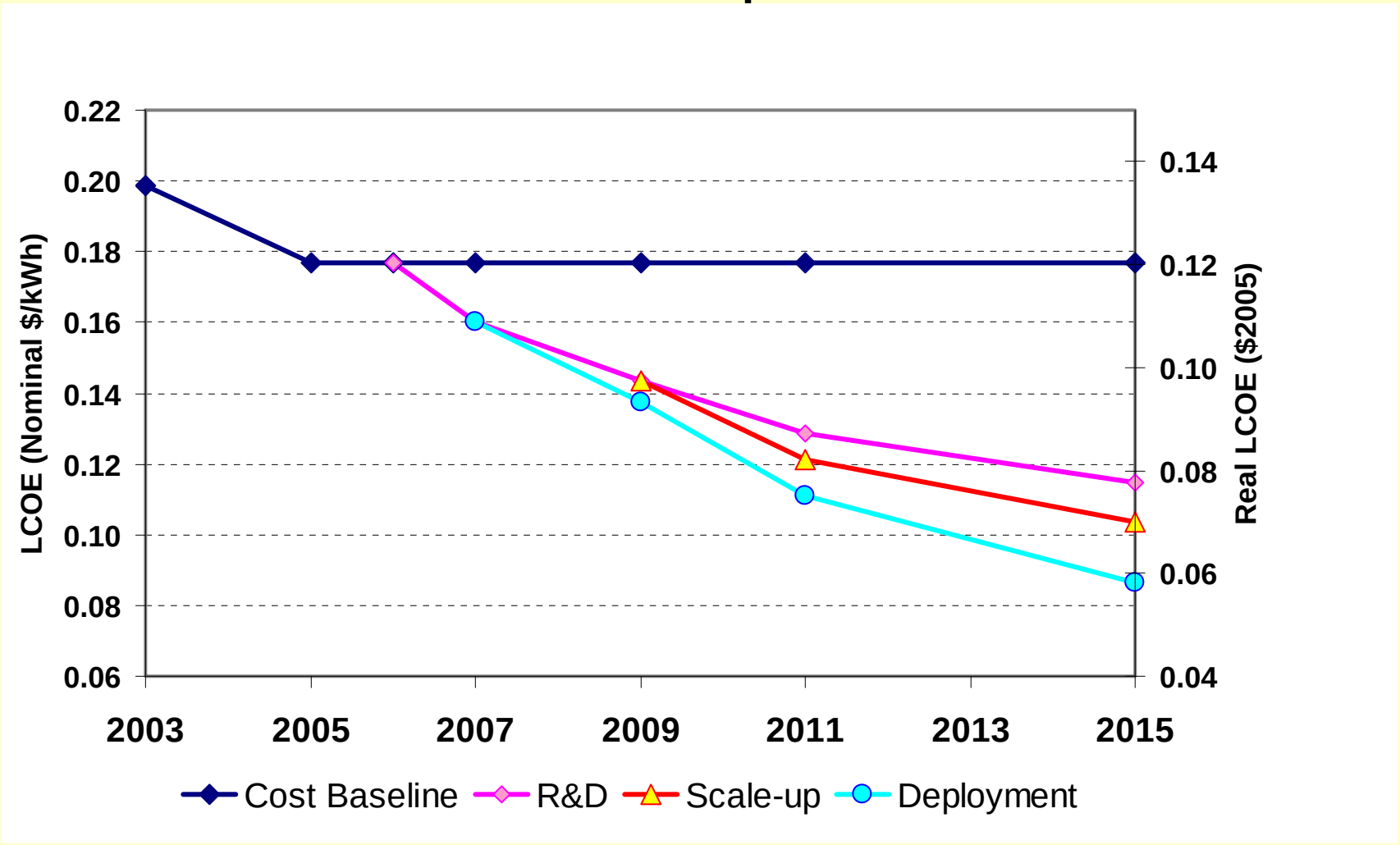
Estimated costs for California

- Based on NREL consultations
- With 30% federal tax credits
- 100-200MW minimum with no thermal storage
- $120-$130/MWh
- Costs are going back up due to materials and limited developers in the market
- Developers are going for larger developments, =>100MW
- Likely deployments @ 2011

Utah vs. Nevada Current Costs

- Nevada Solar One 65 MW CSP
  - With no thermal energy storage, 25% Cap. Factor
- Nevada Solar One cost approx. $3.5 million per MW
  - Cost = $2.45 million/MW after federal tax credits
- Assuming 9% post-tax IRR is needed
  - Cost = $144/MWh for a flat rate 20-year PPA
- Utah's best solar resource would allow for a 20% CF in a CSP plant (no storage
- 65MW CSP plant with similar cost per MW of generating capacity would cost $182/MWh

DOE's Cost Reduction Projections w/ 2000MW market penetration*



*using solar resource of Barstow, CA (7.75-8.06 kW/M2/day. Utah's best is 7.25-7.49).

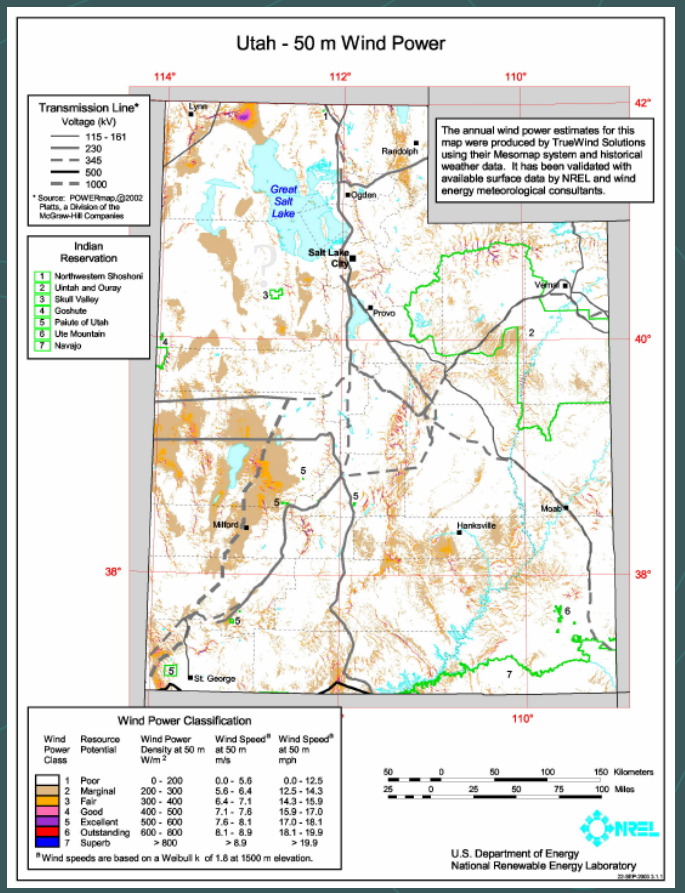
Utah Wind Resource Assessment

Utah State Energy Program

Utah Geological Survey

Utah's Estimated Wind Resources

- Utah's Wind Map
- Computer model
  - Mesoscale data
  - Model uses Jet stream weather patterns
  - Some actual wind data
  - Can be highly inaccurate
  - Developers do not use it



Estimates by the DOE

- WGA's Clean and Diversified Wind Task Force, (Milligan, et al. 2006). Estimated 100 to 570 MW for Utah. Model based on filtering State Wind Map
- Recent DOE WinDS modeling estimated 2.6 GW for Utah by 2024. Based on filtering Utah Wind Map
- Wind Powering America Update report estimates 100-1000 MW, (Flowers. August, 2007).

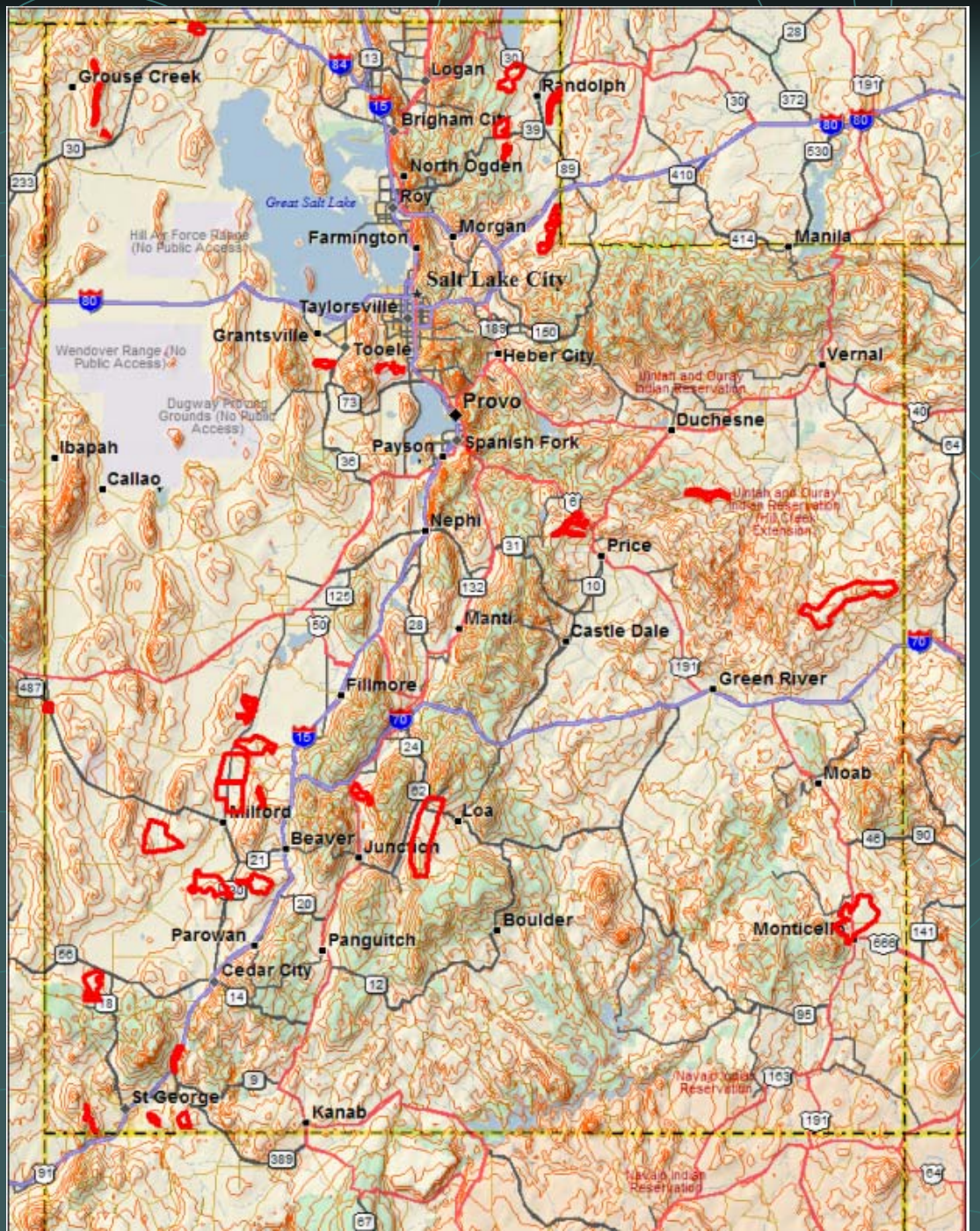
SEP's Methodology for Wind Assesment

- Potential areas identified by SEP and industry
- Data collected from the field (SEP and/or industry)
- Collaborated with industry for data and tech support
  - Thanks to Rich Simon & Tracy Livingston
- 32 potential sites selected throughout the state
- One turbine model used (Clipper C99) 80m hub height
- Two formulas used for turbine placement (ridgelines and open areas)
- Net Capacity Factor Used to estimate MWh production

Methodology for Wind Assessment, cont'd

- Transmission length estimated @ $1million/mile
- Created 2 scenarios for turbine deployment
  - Scenario 1 assumes maximum turbines / km^2
  - Scenario 2 assumes 50% of maximum likely for speculative projects
    - Land use, geology, aesthetics, siting issues, etc.
  - Economic Assumptions
    - 9% post-tax rate of return
    - 20-year project life
    - Federal and state production tax credits

Wind Study Areas



Results—Wind Development Scenario 1

- Maximum deployment scenario 1 estimates 6.8 GW nameplate capacity technically possible

Total MW	Net Capacity Factor (%)	MWh Generated	Net Annual GHG emission reduction (tCO2 equivalent to natural gas plant)
6795	**27.89**	**16,128,857**	**8,359,177**

- Utah 2006 electrical consumption = 26,361GWh
  - -Scenario provides 61% of Utah's electrical demand in 2006
  - -Scenario provides 51% of Utah's electrical demand in 2015
- Net annual GHG emission reduction of 8.4 Million Metric Tons of CO2
  - -22% of Utah Electricity Sector's estimated GHG emissions in 2020

Results—Wind Development Scenario 2

Scenario 2 estimates 3.6 MW of nameplate capacity technically possible

Total MW	Net Capacity Factor (%)	MWh Generated	Net Annual GHG emission reduction (tCO2 equivalent to natural gas plant)
3661	**27.89**	**8,064,429**	**4,344,252**

- Utah 2006 electrical consumption = 26,361GWh
  - -Scenario 2 provides 30.5% of Utah's electrical consumption in 2006
  - -Scenario 2 would produce 25.5% of electricity consumed in 2015
- Net annual GHG emission reduction of 4.3 Million Metric Tons of CO2
  - -12% of Utah Electricity Sector's estimated GHG emissions in 2020

Results—Estimated Cost of Development for Scenario 2

- $/MWh based on Post-tax IRR of 9%
- Included current Federal and Utah PTC
- Assumed $1.8 million/MW installed capacity + transmission ($500,000 to 1 million/mile)
- Pro forma includes other costs, i.e. property taxes, O&M, MACRS, developer fees, etc.
- Three price scenarios for RECs ($2, $5, $15)
    - Non-RPS, RPS, RPS w/ additional requirements

Results—Estimated Cost of Development for Scenario 2

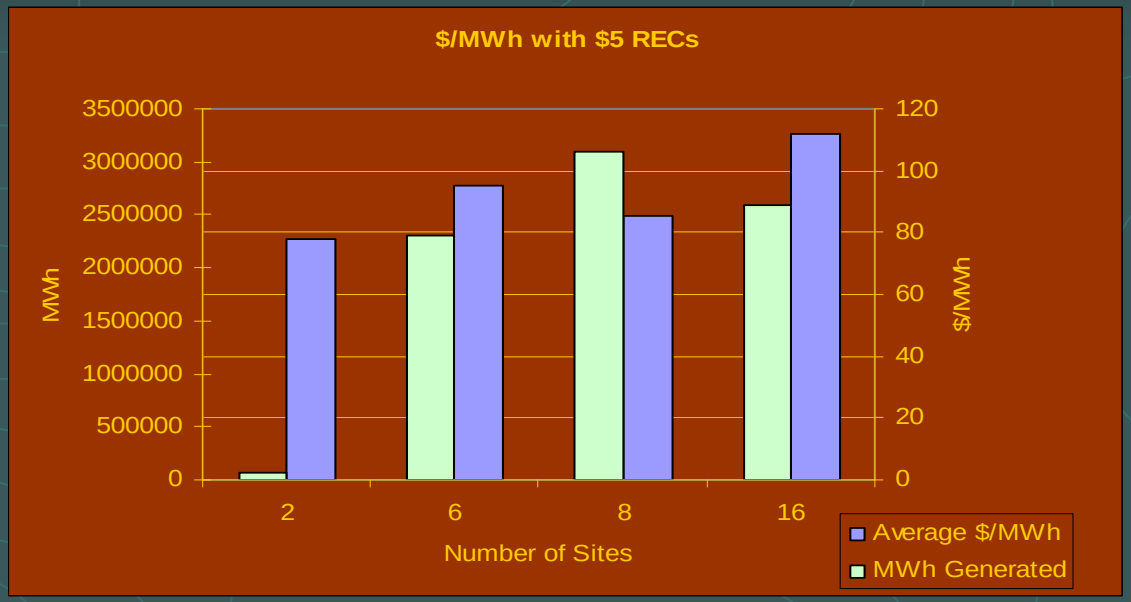
- Average $/MWh for all 32 sites

Total MW	Net Capacity Factor (%)	MWh Generated	$/MWh needed for post-tax IRR of 9% ($2/MWh REC)	$/MWh needed for post-tax IRR of 9% ($5/MWh REC)	$/MWh needed for post-tax IRR of 9% ($15/MWh REC)
3661	**27.89**	**8,064,429**	**$103.00**	**$100.00**	**$88.97**

- RECs typically $2 MWh in non-RPS states
- RECs typically $5-$15 in RPS states

Results—Estimated Cost of Development for Scenario 2 with $5 RECs

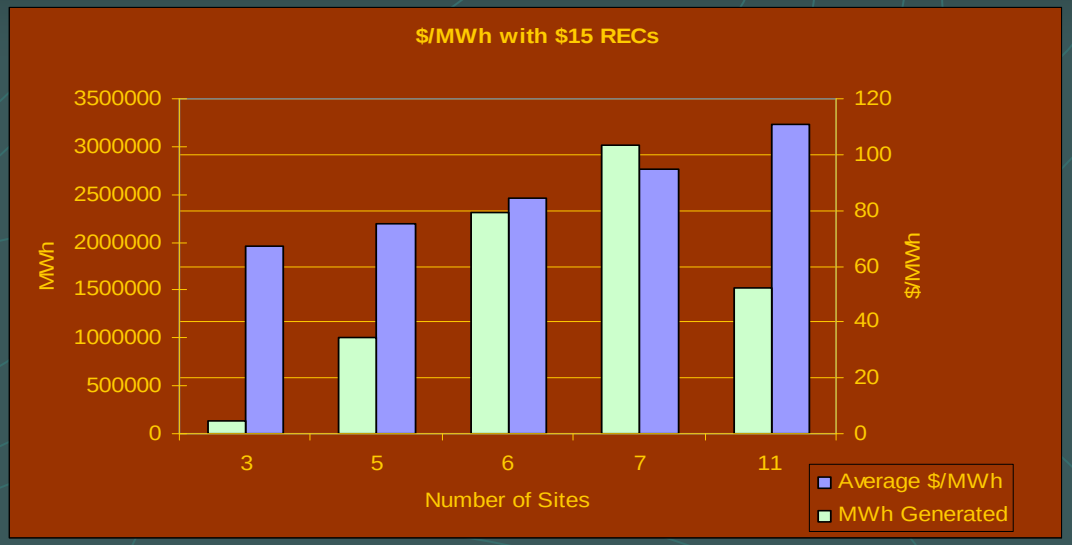
- 2 sites in the $70-79/MWh range
- 8 sites in the $80-89/MWh range
- 6 sites in the $90-100/MWh range
- 16 sites in the >$100/MWh range
- Overall average $MWh to meet 9% IRR is $100



$/MWh	Number of Sites	MW of Capacity	Average Net Capacity Factor	MWh Generated	Average $/MWh needed for post-tax IRR of 9% ($5/MWh REC)
>100	16	1,082	28	2,595,347	112
100-90	8	1,231	28	3,094,826	85
80-89	6	1,276	30	2,312,187	95
70-79	2	45	32	62,070	78
Total/Average	**32**	**3,634**	**28.44**	**7,997,044**	**100**

Results—Estimated Cost of Development for Scenario 2 with $15 RECs

- 3 sites in the $60-69/MWh range
- 5 sites in the $70-79/MWh range
- 6 sites in the $80-89/MWh range
- 7 sites in the $90-100/MWh range
- 11 sites in the >$100/MWh range
- Overall average $MWh to meet 9% IRR is $89



$/MWh	Number of Sites	MW of Capacity	Net Capacity Factor	MWh Generated	Average $/MWh needed for post-tax IRR of 9% ($15/MWh
>100	11	436	27	1,517,718	111
100-90	7	646	28	3,022,527	95
80-89	6	1,231	28	2,312,187	84
70-79	5	1,221	29	1,010,245	75
60-69	3	100	31	134,368	67
Total/Average	**32**	**3,634**	**28.44**	**7,997,044**	**89**

National Cost Comparison

- 2007 DOE Wiser & Bolinger report capacity-weighted average sales price for 2006 was ~$49/MWh (with a range of $30- $64MWh).
- Report concludes that $/MWh costs are rising
- Construction prices continue to go up…$2,000/MW for 2009. How long????

Summary

- There is no magic bullet
  - Utah has abundant renewable resources
    - But for no technology are they exceptional
  - Some low-cost projects possible
    - But likely to account for relatively small portion of electricity demand
  - Large-scale renewables projects will cost more
- For perspective…
  - Utah has cheap electricity right now
    - Utah = 5.99 cents / kWh
    - National Average = 8.85 cents / kWh
  - Costs likely to rise in future, regardless of move to renewable resources